

Discussion of Safety Criteria

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Those who are not familiar with the subject tend to think that the study of the safe use of RF energy is in its infancy. This is not the case. Studies of the biological effects associated with exposure to RF energy and the development of safety standards for human exposure based on these studies is a continuous process that has been on-going throughout the world for more than six decades. The first safety guidelines were proposed in the early 1950's when concern first arose in the US about exposure to electromagnetic energy, particularly at the microwave frequencies associated with military radars. Although the guidelines first recommended in the 1950's varied considerably from organization to organization, eventually most organizations in the Western World adopted limits similar to those adopted by the FCC. The basis of contemporary safety limits, called "basic restrictions," was first proposed in 1981 by a committee sponsored by National Council on Radiation Protection and Measurements¹ (NCRP) [B1] and affirmed by an accredited American National Standards Institute (ANSI) committee as the basis of their 1982 RF safety standard [B2]. In 1986, an NCRP committee adopted the same basic restrictions as the basis of their 1986 recommendations on RF safety [B3]. The ANSI committee, now the Institute of Electrical and Electronics Engineers (IEEE)² International Committee on Electromagnetic Safety (ICES), reaffirmed these same basic restrictions in 1991 [B4] and again in 2005 [B5] following extensive critical reviews of the scientific literature. In fact, every recent major independent review of the science continually supports the validity of these basic restrictions.

The scientific literature related to biological effects of RF energy is highly diverse, both in terms of scientific quality and in terms of relevance to possible health and safety risks to humans. Occasionally media reports on the results of some new study conclude that exposure to low-level radiowaves could be harmful. In many cases these reports are based on press releases by a researcher or the researcher's institution. Many such reports include gratuitous speculation suggesting that, based on the results of the study, devices such as mobile phones, microwave ovens or even computer display terminals might be unsafe. Even though many such reports describe only preliminary or unconfirmed results of studies that have not been subjected to peer-review or accepted for publication and might not even be relevant to human health, they are sometimes given an inordinate amount of attention. In many cases it is not the scientist who creates significance by postulating adversity, but rather the media because of the implied "newsworthiness" of the story. In bioelectromagnetics, as in most areas of science, it takes a considerable amount of time and effort for scientists to sift and winnow facts from conjecture, and while most of these controversial reports and reported preliminary results of unpublished studies do not stand up to scientific scrutiny, or cannot be related to adverse human health, they nevertheless are the focus of concern to the lay person because of the alarming way they are interpreted and presented.

¹. NCRP is a non-profit corporation chartered by Congress "To collect, analyze, develop and disseminate in the public interest information and recommendations about (a) protection against radiation (referred to herein as radiation protection) and (b) radiation measurements, quantities and units, particularly those concerned with radiation protection." Although more focused on "ionizing radiation;" e.g., X-rays, gamma-rays, nuclear radiation, NCRP has developed several reports that address radiofrequency issues and their recommendations are the basis of the FCC guidelines at the frequencies of interest.

². IEEE is a non-profit technical professional society with more than 400,000 members in 160 countries. Within IEEE are a number of societies, including the Consumer Electronics Society, Education Society, Electromagnetic Compatibility Society, Engineering in Medicine and Biology Society, Information Theory Society, Neural Networks Society, Society on Social Implications of Technology, plus about twenty more. IEEE membership is not a requirement of participating on this IEEE committee or any of its subcommittees.

Contrary to what some of these stories may imply, a lot is known about the safety of electromagnetic energy at radiofrequencies. What is important is that in spite of the tremendous amount of research that has been reported in this field over the past five or six decades, there is a complete lack of any reliable evidence showing that exposure to RF energy at levels below contemporary safety guidelines is harmful to humans, including children. Moreover, the reliable scientific evidence clearly demonstrates that biological effects associated with exposure to RF energy are “threshold effects.” This means that effects are only associated with exposures above a specific intensity – regardless of the exposure duration.³ The threshold exposure levels at which potentially harmful effects might occur have been independently established and confirmed many times over. These thresholds, with large built-in margins of safety, are the bases of contemporary safety guidelines and recommendations, such as those supported or developed independently by expert panels and committees sponsored by the IEEE [B5], the NCRP [B3], the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [B6], Health Canada [B7], the Health Council of the Netherlands, [B8], [B9], [B18] the National Radiological Protection Board (NRPB) in the UK [B10], the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) [B11], and the safety guidelines adopted by the FCC [B12]. The FCC safety guidelines, which are a composite of the most restrictive portions of the standards and recommendations developed by committees of the IEEE and NCRP, and with which all wireless facilities in the US must comply, are supported by the federal public health agencies. Table B-1 is a summary of the corresponding safety criteria recommended by various organizations throughout the world.

In spite of speculations about the possibility of effects occurring at levels below the safety guidelines, the fact is that the only effects reliably demonstrated in humans or laboratory animals are related to RF exposure at levels far in excess of the guidelines. This is not to say that exposure to radiowaves at any intensity cannot cause untoward effects. Exposures at levels far higher than the safety guidelines can lead to whole or partial-body heating and, possibly, burns from touching an object on which high RF currents are flowing.⁴ The safety guidelines protect humans from these effects. The overwhelming consensus of the international scientific community is that as long as the system complies with science-based safety guidelines there is no adverse health risk, i.e., exposure to RF energy at levels at or below the safety guidelines is safe.

In part due to the proliferation of wireless devices and our reliance on their usage, during the past several years a number of independent critical reviews of the relevant scientific literature were undertaken by expert panels throughout the world. Many of these reviews focused on mobile telephones and base stations, but they also addressed the adequacy of contemporary safety standards. The following excerpts from some of the expert reviews by these panels summarize the consensus of the scientific community:

- In 2004, the NRPB (United Kingdom) issued a new report on the health effects from RF electromagnetic fields. Their conclusion is “...*the weight of evidence now available does not suggest that there are adverse health effects from exposure to RF fields below guideline levels, but published work on RF exposures and health has limitations.*” [B10]
- In 2005, the NRPB issued another report on the health effects of RF electromagnetic fields, particularly addressing mobile radio (cellphones and cellular base stations) and the adequacy of current exposure guidelines. Their conclusion is “*In aggregate the research published since the IEGMP report does not give cause for concern.*” [B13]

³. This is a completely different phenomenon than that associated with exposure to much more energetic forms of radiation such as X-radiation, nuclear radiation, etc., (called “ionizing radiation”) where exposures even at low levels might damage genetic material.

⁴. There are no components associated with the base-station installation where this is possible – not even the antennas themselves.

- In April 2006, the latest revision of IEEE standard C95.1 was published. This revision represents the culmination of an intensive review of approximately 1300 relevant papers from the world's peer-reviewed scientific literature by a committee of more than 120 scientists and engineers from around the world, representing more than 20 countries. The conclusion of the committee, which operated through an open consensus process, transparent at every level, is that there is no convincing evidence that would suggest lowering the values of the basic restrictions found in the 1991 C95.1 standard is warranted. [B4]
- In 2006, the World Organization in Fact sheet No. 304, concluded "*Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects.*" [B14]
- In 2007, in a Clarification Statement regarding children and mobile phones, the World Health Organization concluded "*To date, all expert reviews on the health effects of exposure to RF fields have reached the same conclusion: There have been no adverse health consequences established from exposure to RF fields at levels below the international guidelines on exposure limits published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998).*"[B15]
- In 2008, the International Agency for Research on Cancer (World Cancer Report 2008) On the issue of Cancer causation: "*The evidence for the carcinogenicity of radio-frequency fields is even less clear. A few epidemiological studies in occupational settings have indicated a possible increase in the risk of leukaemia or brain tumours, while other studies indicated decreases. These studies suffer from a number of limitations. The experimental evidence is also limited, but suggests that radio- frequency fields cannot cause DNA mutations. The lack of reproducibility of findings limits the conclusions that can be drawn.*" [B16]
- In February 2009, the European Commission's independent Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) stated "*It is concluded from three independent lines of evidence (epidemiological, animal and in vitro studies) that exposure to RF fields is unlikely to lead to an increase in cancer in humans....*" [B17]
- In March 2009, The Health Council of the Netherlands published Electromagnetic Fields: Annual Update 2008 (fifth annual update). "*The Committee further discusses the relationship between electromagnetic fields and brain activity and that between electromagnetic fields and health symptoms. In both cases the Committee concludes that there is no scientific evidence that exposure to environmental levels of radiofrequency electromagnetic fields causes health problems*" [B18]. For earlier HCN updates and statements see [B8], [B9].
- In August 2009, ICNIRP issued "Statement on the 'Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)". "*Since publication of the ICNIRP "Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)" in 1998 science has evolved (see also below ICNIRP RF review). At this date the health risk assessment concerning radiofrequency fields by the World Health Organization is still underway. In view of establishing the validity of its current guidance in relation to RF exposure, ICNIRP is issuing this statement, which identifies the main scientific advancements relevant to that field. In conclusion, ICNIRP reconfirms its recommendations on radiofrequency for the moment.*" [B19]
- In May 2010, the Institution of Engineering and Technology (IET) issued a Position Statement on "The Possible Harmful Biological Effects of Low-Level Electromagnetic Fields of Frequencies up to 300 GHz" in which they state – "*Biological Effects Policy*

Advisory Group (BEPAG) on low-level EMFs has concluded that the balance of scientific evidence to date does not indicate that harmful effects occur in humans due to low-level exposure to EMFs. This conclusion remains the same as that reached in its previous position statements, the last being in May 2008, and our findings have not been substantially altered by the peer-reviewed literature published in the past two years... Environmental power levels from base stations, often a cause of public concern, are broadly similar to those from other broadcast radiofrequency sources such as television and radio transmitters and are many times lower than the peak values experienced when using a mobile-phone handset.” [B20]

- In December 2010, the Swedish Radiation Safety Authority (SSI), December 2010, Seventh Annual Report: *“Available data do not indicate any risks related to exposure to RF from base stations or radio or TV antennas. Taking into account also the low levels of exposure that these sources give rise to, health effects from transmitters are unlikely.”* [B21]
- In February 2011, The independent Spanish expert committee CCARS (Comité Científico Asesor en Radio-frecuencias y Salud), has published a literature review and an opinion on cellular telephony and health. The experts conclude: *“In agreement with various competent organizations, today there no scientific reason that justifies reducing present exposure limits to cellular telephony electromagnetic fields, for the general public as well as for professional exposure.”*[B22]
- In 2011, the UK National Health Services (NHS) – Mobile Phones and Base Stations: *“The levels of radio waves emitted from base stations in places where the public have access are generally found to be hundreds or thousands of times below the health and safety guideline limits.”* [B23]
- In May 2011, Dr Christopher Wild, Director of the International Agency for Research on Cancer (IARC) announced the classification of radiofrequency electromagnetic fields in Group 2B *“Possibly carcinogenic to humans” based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use.”* Dr Jonathan Samet, overall Chairman of the IARC’s classification working group said: *“The evidence, while still accumulating, is strong enough to support a conclusion and the 2B classification. The conclusion means that there could be some risk, and therefore we need to keep a close watch for a link between cell phones and cancer risk.”* [B24]
- In June 2011, the World Health Organization (WHO) released a revised version of its fact sheet 193, “Electromagnetic fields and public health: mobile phones”, taking into account the classification of RF fields into Group 2B (possibly carcinogenic to humans) by the International Agency for Research on Cancer (IARC). The revised fact sheet includes the following statements: *“A large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects have been established as being caused by mobile phone use”* and *“The largest retrospective case-control study to date on adults, Interphone, [...] found no increased risk of glioma or meningioma with mobile phone use of more than 10 years.”* [B25]
- Institut National du Cancer (INCa), France, June 2011 following the classification of radiofrequency fields into Group 2B by the IARC, the French National Cancer Institute (INCa) has updated its fact-sheet on cell phones and cancer risk. It states: *“Recently published expert reports have established, from the different studies available, an assessment of the knowledge in this domain. Today, the scientific community has not evidenced a link between the use of a cell phones and an increased risk of cancer.”* [B26]
- In July 2011, in response to a question from Greek MEP Kriton Arsenis to the EU Parliament, John Dalli, European Commissioner for Health and Consumer Policy, responded

on behalf of the Commission with the following: *“This classification is based on an increased risk of malignant brain tumors observed in heavy users of mobile phones and in some of the epidemiological studies conducted so far. These findings were judged as providing ‘limited’ evidence for a possible cancerogenic effect of fields from mobile phones. The data assessed was considered inadequate to draw conclusions on cancers and for any other types of exposure scenarios (environmental or occupational exposure) and exposure sources, including base stations.”*[B27]

- In July 2011, a report published on behalf of the WHO IARC Monograph Working Group included the statement – *“Typical exposures to the brain from rooftop or tower-mounted mobile-phone base stations and from TV and radio stations are several orders of magnitude lower than those from global system for mobile communications (GSM) handsets.”* [B28]
- In July 2011, the International Commission on Non-Ionizing Radiation Protection’s (ICNIRP) Standing Committee on Epidemiology has found that the cell phone-brain tumor link is increasingly questionable. In an article published in Environmental Health Perspectives, the authors conclude: *“Although there remains some uncertainty, the trend in the accumulating evidence is increasingly against the hypothesis that mobile phone use can cause brain tumours in adults.”* [B29]
- In July 2011, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) revised EME Series Fact Sheet #9 - What about base stations and telecommunications towers - are there any health effects?: *“The weight of national and international scientific opinion is that there is no substantiated evidence that RF emissions associated with living near a mobile phone base station or telecommunications tower poses a health risk...”* [B30]
- In October 2011, Health Canada “Safety of Cell Phones and Cell Phone Tower” [updated]: *With respect to cell phone towers, as long as exposures respect the limits set in Health Canada’s guidelines, there is no scientific reason to consider cell phone towers dangerous to the public...”* [B31]
- In October 2011, the Health Council of the Netherlands Advisory Report – Influence of radiofrequency telecommunication signals on children’s brains: *“There is no scientific evidence for a negative influence of exposure to electromagnetic field of mobile telephones, base station antennas or Wi-Fi equipment on the development and functioning of the brain and on health in children. This is the main conclusion of an advisory report the Health Council presented today to the State Secretary of Infrastructure and the Environment.”* [B32]
- In February 2012, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) updated its fact sheet *Mobile Telephone Communication Antennas and Health Effects*. ARPANSA concludes: *“No adverse health effects are expected from continuous exposure to the RF radiation emitted by the antennas on mobile telephone base station towers.”* [B33]
- In April 2012, the Health Protection Agency’s independent Advisory Group on Non-ionising Radiation (AGNIR), United Kingdom, provided an update of its 2003 report. The group reviewed the scientific evidence on exposure to RF electromagnetic fields, which are produced by mobile telephone technologies and other wireless devices. The HPA concludes: *“In summary, although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guideline levels causes health effects in adults or children.”* [B34]
- A report released by the Swedish Council for Working Life and Social Research (FAS) summarizes the last ten years of research on the health risks associated with exposure to RF fields from mobile telephony equipment.

According to the report:

“Overall, the data on brain tumor and mobile telephony do not support an effect of mobile phone use on tumor risk, in particular when taken together with national cancer trend statistics throughout the world.”

Concerning electromagnetic hypersensitivity (EHS), the authors point out that more than 15 provocation studies have been conducted.

“These studies have not been able to demonstrate that people experience symptoms or sensations more often when the fields are turned on than when they are turned off.”

The experts group concluded that more than a decade of extensive research *“has found no evidence for health risks below current exposure guidelines.”*[B35]

- The European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN) has updated its 2010 report. The new report reviews the most recent researches studying the effects of low, intermediate and high frequencies on human health. The conclusions of the European experts are similar to those of their previous report.

Concerning high frequency fields, the report concludes:

“Inclusion of recent data regarding adult brain tumours necessitates a revision to the original classification, and [the evidence] is now considered to be best described as being limited.

“[...] Inclusion of recent data on other endpoints has not necessitated any revisions to the existing consensus opinions of EMF NET (2009) or SCENIHR (2009). Overall, the strength of evidence for [the studied] outcomes remains as inadequate.”

Note: *In order to evaluate the strength of evidence for any given endpoint, a four level classification scheme has been used by the EFHRAN experts, based on the system devised by IARC: sufficient evidence, limited evidence, inadequate evidence and evidence suggesting a lack of effects.*[B36]

- In December 2013 a statement by the Nordic Radiation Safety Authorities was published on exposure from mobile phones, base stations and wireless networks:
Specifically regarding exposure from base station transmitters and wireless local area networks – *“Global wireless communication technology is based on an extensive network of base stations that transmit and receive data using signals based on radio waves. Wireless local area networks (WLAN, Wi-Fi) also use radio waves for communication. Recent surveys have shown that despite the sharp increase in applications using wireless technology, the level of radio wave exposure in public outdoor areas as well as indoor in schools, offices and dwellings is far below the exposure limits.”*[B37]
- In April 2014 the Royal Society of Canada published a report on their review of Health Canada’s Safety Limits for Exposure to Radiofrequency Fields (which are similar to the FCC safety guidelines). The Panel concluded that – *“...the balance of evidence at this time does not indicate negative health effects from exposure to RF energy below the limits recommended in the Safety Code.”*[B38]
- In January 2015, the European Commission's independent Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) updated the 2009 SCENIHR Opinion ([B17]) in light of newly available information. Special consideration was given to areas where important knowledge gaps were identified including biophysical interaction mechanisms and the potential role of co-exposures to environmental stressors. The Committee concludes *“The results of current scientific research show that there are no*

evident adverse health effects if [EMF] exposure remains below the levels set by current standards” [B39].

- In March 2015 the Swedish Radiation Safety Authority (SSM) released a report “Recent Research on EMF and Health Risk - Tenth report from SSM’s Scientific Council on Electromagnetic Fields, 2015.” The Scientific Council concludes “*In line with previous studies, new studies on adult and childhood cancer with improved exposure assessment do not indicate any health risks for the general public related to exposure from radiofrequency electromagnetic fields from far-field sources, such as base stations and radio and TV transmitters. There is no new evidence indicating a causal link to exposure from far-field sources such as mobile phone base stations or wireless local data networks in schools or at home*” [B40].
- In June 2015, Health Canada published a revision of its Safety Code 6 [B40]. While the basic restrictions specified in this safety code have not changed since the previous version (2009), the reference levels have been updated to either account for dosimetric refinements in recent years or where feasible, or to harmonize with those of the International Commission on Non Ionizing Radiation Protection (ICNIRP), which are similar to those of the FCC. They conclude that “*At present, there is no scientific basis for the occurrence of acute, chronic and/or cumulative adverse health risks from RF field exposure at levels below the limits outlined in Safety Code 6,*” and state “*The hypotheses of other proposed adverse health effects occurring at levels below the exposure limits outlined in Safety Code 6 suffer from a lack of evidence of causality, biological plausibility and reproducibility and do not provide a credible foundation for making science-based recommendations for limiting human exposures to low-intensity RF fields.*” Health Canada scientists have concluded (and the Royal Society of Canada has agreed) on the basis of current scientific data, that no adverse health effects will occur from exposure to RF fields at the levels permitted by Safety Code 6. [B41]

These reports largely addressed concerns about possible health effects of exposure to RF energy. Each of the expert panels examined a large body of evidence for hazards, including reports of “non thermal” effects, but the only convincing evidence that could be related to adverse effects in humans involved high exposure levels and obviously thermal phenomena. Expert committees such as NCRP, IEEE ICES and ICNIRP have each independently reached the same conclusion and are very explicit about the lack of reliable evidence for possible hazards from low-level exposures or “non-thermal” effects.

The collective credible evidence, including the results of epidemiological studies of individuals exposed to radiowaves and laboratory studies of animals exposed both short-term and throughout their entire lifetimes, has not demonstrated that exposure to radio frequency energy at levels that comply with contemporary science-based safety guidelines, such as those adopted by the FCC, can affect biological systems in a manner that might lead to, or augment, any health effect or interfere with the operation of medical devices such as hearing aids or implanted cardiac pacemakers.

Table B-1
Summary of International, Federal, State and Consensus Safety Criteria for Exposure to RF Energy
(Frequencies Used for Personal Wireless Communication Systems and land-mobile radio: 450 – 3000 MHz)

Organization/Government Agency	Exposure Population	Power Density (<i>S</i>) ($\mu\text{W}/\text{cm}^2$)	
International Guidelines			
International Commission on Non-Ionizing Radiation Protection (1998), <i>Health Physics</i> , Vol. 74, No. 4, pp 494-522 ¹	Occupational	$S = f / 0.4$ ($f < 2000$ MHz)	$S = 5000$ ($f \geq 2000$ MHz)
	Public	$S = f / 2$ ($f < 2000$ MHz)	$S = 1000$ ($f \geq 2000$ MHz)
Federal Requirements			
Federal Communications Commission (47 CFR §1.1310) ²	Occupational	$S = f / 0.3$ ($f < 1500$ MHz)	$S = 5000$ ($f \geq 1500$ MHz)
	Public	$S = f / 1.5$ ($f < 1500$ MHz)	$S = 1000$ ($f \geq 1500$ MHz)
Institute of Electrical and Electronics Engineers (IEEE Standard C95.1-2005) ³	Occupational	$S = f / 0.3$ ($f < 3000$ MHz)	$S = 10,000$ ($f \geq 3000$ MHz)
	Action Level ⁴	$S = f / 2$ ($f < 2000$ MHz)	$S = 1000$ ($f \geq 2000$ MHz)
National Council on Radiation Protection & Measurements (NCRP Report 86, 1986)	Occupational	$S = f / 0.3$ ($f < 1500$ MHz)	$S = 5000$ ($f \geq 1500$ MHz)
	Public	$S = f / 1.5$ ($f < 1500$ MHz)	$S = 1000$ ($f \geq 1500$ MHz)
State Codes			
New Jersey (NJAC 7:28-42)	Public	$S = f / 0.3$ ($f < 1500$ MHz)	$S = 10,000$ ($f \geq 1500$ MHz)
Massachusetts (Department of Health 105 CMR 122)	Public	$S = f / 1.5$ ($f < 1500$ MHz)	$S = 1000$ ($f \geq 1500$ MHz)
New York State ⁵	Public	$S = f / 1.5$ ($f < 1500$ MHz)	$S = 1000$ ($f \geq 1500$ MHz)
NOTE— <i>f</i> is in MHz			

¹ Update of the 1989 International Radiation Protection Association (IRPA) guidelines. Reaffirmed in 1997 and published, with modification, in 1998.

² All licensees are required to comply with the limits outlined in 47 CFR §1.1307.

³ Incorporates IEEE Standard C95.1-1991, IEEE Standard C95.1a-1998 and C95.1b-2004.

⁴ The “action level” is defined as the level at which mitigative measures (e.g., an RF safety program) are implemented to protect against exposures that could exceed the upper tier (occupational limits).

⁵ State of New York Department of Health follows the recommendations in NCRP Report 86.

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